Clouds and the Earth's Radiant Energy System (CERES)

Data Management System

Convolution of Imager Cloud Properties with CERES Footprint Point Spread Function (Subsystem 4.4)

CERES Release 2 Test Plan

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1.0 Introduction

The Clouds and the Earth's Radiant Energy System (CERES) is a key component of the Earth Observing System (EOS). The CERES instruments are improved models of the Earth Radiation Budget Experiment (ERBE) scanner instruments, which operated from 1984 through 1990 on the National Aeronautics and Space Administration's (NASA) Earth Radiation Budget Satellite (ERBS) and on the National Oceanic and Atmospheric Administration's (NOAA) operational weather satellites NOAA-9 and NOAA-10. The strategy of flying instruments on Sun-synchronous, polar orbiting satellites, such as NOAA-9 and NOAA-10, simultaneously with instruments on satellites that have precessing orbits in lower inclinations, such as ERBS, was successfully developed in ERBE to reduce time sampling errors. CERES will continue that strategy by flying instruments on the polar orbiting EOS platforms simultaneously with an instrument on the Tropical Rainfall Measuring Mission (TRMM) spacecraft, which has an orbital inclination of 35 degrees. In addition, to reduce the uncertainty in data interpretation, and to improve the consistency between the cloud parameters and the radiation fields, CERES will include cloud imager data and other atmospheric parameters. The first CERES instrument is scheduled to be launched on the TRMM spacecraft in 1997. Additional CERES instruments will fly on the EOS-AM platforms, the first of which is scheduled for launch in 1998, and on the EOS-PM platforms, the first of which is scheduled for launch in 2000.

1.1 Document Overview

The Release 2 delivery to the Langley DAAC for the Convolution of Imager Cloud Properties with CERES Footprint Point Spread Function Subsystem (4.4) consists of a set of four tar files and documentation describing the data and software contained in the tar files. Note that this is part of a joint delivery with Subsystem 4.1 - 4.3, CERES Cloud Retrieval. The tar files contain the Subsystem 4.4 Release 2 software (along with the Subsystem 4.1-4.3 Release 2 software); the ancillary data sets required for the software to execute; the test data and other support data required to execute both Subsystems; the output data files that were generated on the science computing facility, blizzard; and the documentation submitted with the delivery, including Test Plans for both this Subsystem and Subsystem 4.1 - 4.3.

This document, the CERES Release 2 Test Plan for the Convolution of Imager Cloud Properties with CERES Point Spread Function Subsystem (4.4), provides a description of the Subsystem 4.4 Release 2 software and supporting data files and explains the procedures for installing, executing, and testing the software. A section is also included on validating the results of executing the software.

The document is organized as follows.

1.2 Subsystem Overview

1.2.1 Convolution of Imager Data with CERES Point Spread Function Subsystem (4.4)

The major objective of Subsystem 4.4 (FOOTPRINT) is to use high spectral and spatial resolution cloud imager data to determine cloud microphysical and optical properties within the larger CERES footprint. This provides a set of cloud properties optimally designed for studies of the role of clouds in the Earth's radiation budget, and enables the cloud physical properties to be tied to the cloud broadband radiative properties in a consistent manner. This initial estimate of cloud properties is modified in Subsystem 5 to obtain consistency in cloud properties and Top-of-the-Atmosphere (TOA) broadband radiative fluxes.

The major objectives of this Subsystem are illustrated in Figure 1-1 and include:

1. Locate imager pixels within a CERES footprint by calculating the value of the Point Spread Function (PSF) for each pixel with respect to the centroid of the CERES field of view (FOV). If the PSF value exceeds a specified threshold value, the pixel is included in the footprint.
2. Accumulate statistics of cloud properties for all imager pixels within the CERES footprint and write the footprint records to the intermediate Single Satellite Footprint TOA and Surface Fluxes Clouds (SSF) output file.
3. Write diagnostic and statistical information from each run to the Quality Control (QC) report files.

The primary input data sets for the FOOTPRINT Subsystem are:

1. The CERES Instrument Earth Scans (IES) data product contains time of observation, geolocation data, and filtered radiances for each footprint in spatial order. The CERES footprint effective diameter is 10 km for Tropical Rainfall Measuring Mission (TRMM) spacecraft and 20 km for EOS AM and PM spacecraft. IES file from TRMM is used as the test data sets for Release 2.
2. The cloud imager data from Advanced Very High Resolution Radiometer (AVHRR), Visible Infrared Scanner (VIRS), or Moderate-Resolution Imaging Spectroradiometer (MODIS) are processed by Subsystems 4.1 - 4.3 and passed to FOOTPRINT via the Imager Pixel Data file, commonly designated "Cookiedough." This file represents a two-dimensional array (N scanlines by M pixels per scanline), with a data structure associated with each pixel containing pixel location, viewing geometry, observation time, multispectral radiance data, scene type, and cloud properties as determined in Subsystems 4.1 through 4.3.

The output science product is the intermediate SSF product (SSF_Int). The intermediate SSF is subsequently processed and completed by Subsystem 4.5-4.6, and the resulting final SSF is an hourly CERES archival product that contains footprint geometry, radiance information, and the statistics for full footprint, clear footprint, cloudy footprint and overlap footprint areas.

The secondary output products are Status Message File (SMF) log files and the quality control reports. SMF logs contain system-level diagnostic messages related to the execution of the FOOTPRINT program and provide a mechanism for tracing run-time error conditions. The quality control reports contains processing information, informative messages, and statistics. In Release 2, Subsystem 4.4 creates both a formatted (ASCII) report file (QCRPRT) and a binary report file (QCBin) which is intended to be postprocessed by one or more of a variety of flexible programs for browsing, display, or data extraction.

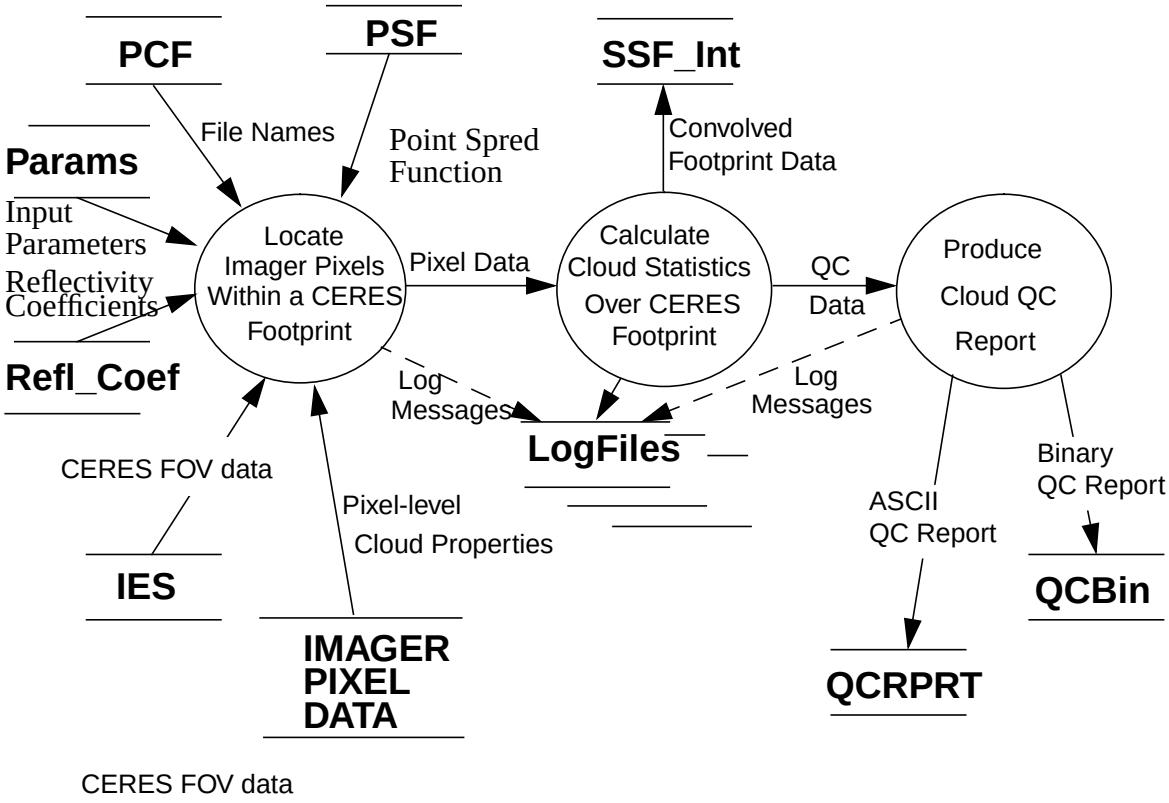

Figure 1-1. Top Level Data Flow Diagram for Subsystem 4.4

2.0 Test Environment

2.1 External Interface Requirements

Simulated Data Included in Delivered Files:
The Instrument Earth Scan (IES) file included in the DAAC delivery package is a primary input file for Subsystem 4.4. The test file included with the Release 2 DAAC delivery is a normal cross-track Fixed Azimuth Plane Scan (FAPS) mode, with the CERES footprint density of 660 footprints per complete scan. The IES files are created by Subsystem 1 (Instrument).

CERESLIB Routines Used:
Subsystem 4.4 uses the CERES Library (CERESlib) routines shown in Table 2-1:

Table 2-1. CERESlib Routines Used by Subsystem 4.4 (1 of 2)

File Name	Description
ceres_defaults	Provides standard default fill values for all available data types
Header_Time (in cereslib module **ceres_time**)	Returns current system time in ASCII string format
jul_cal (from module **ceres_time**)	Converts time from Julian day to yymmddhhmmss format.
ceres_status	Provides standard global variable values for file operation status and keyword indicators
ceres_constants	Provides standard values for universal constants such as Pi
ssf_typdef	Module that defines the data structure and provides file open/ close/read/write operations for the SSF_Int and final SSF data products
ssfqc_typdef	Module that defines the data structure and provides file open/ close/read/write operations for the binary quality control report
WriteReport (from module **MSG**)	Wrapper for writing messages to log file using Toolkit
WriteStatus (from module **MSG**)	Wrapper for writing status messages to log file using Toolkit
OpenFile (from module **IO**)	Wrapper for opening files using Toolkit
CloseFile (from module **IO**)	Wrapper for closing files using Toolkit
AddInputFile (from module **IO**)	Wrapper for adding a HDF file to the metadata input pointers

Table 2-1. CERESlib Routines Used by Subsystem 4.4 (2 of 2)

File Name	Description
f90_kind	Module that provides global variables defining Fortran 90 “KIND” values available for the specific f90 compiler
NewPage (from module **QCHeader**)	Provides form feed capability for writing QC report
WriteHeader (from module **QCHeader**)	Provides method for writing standard header to QC report
ReadMeta (from **meta_util**)	Read metadata header from an HDF or the metadata load file
WriteMeta (from **meta_util**)	Write metadata to the load file and header to direct access
GetParam (from module **PCF**)	Retrieve parameters from the Process Control File.
GetFileName(from module **PCF**)	Retrieve file names from the Process Control File.
ies_qual_flag (from module **quality_file**)	Returns values for various variables packed in the IES quality flag.
Check_bnds (from module **range_check)**	Checks the range of elements within the SSF.
get_unitnum (from module **tk_replace)**	Returns unit number from opening a file.

2.2 Directory Structure and File Descriptions

A complete depiction of the directory hierarchy used by the combined clouds Subsystems 4.1 - 4.4 is presented in Appendix B, and a series of file description tables are presented in Appendix C of this Test Plan.

3.0 Software and Data File Installation Procedures

This section describes how to install the Subsystem 4.4 software in preparation for making the necessary test runs at the Langley DAAC. The installation procedures include instructions for uncompressing and untarring the cloud files, properly defining environmental variables, and compiling the cloud programs. Note that these tar files combine Subsystems 4.1 - 4.3 and 4.4, so that both Subsystems will be installed at the same time.

3.1 Installation

Software/Data File Install Procedure:

1. The scripts, makefiles, and Process Control files in the Subsystem 4.1 - 4.3 and 4.4 delivery package make use of the following environment variables:

   $CERESLIB
   $CERESHOME
   $PGSDIR - (Toolkit version 5.2.1)
   $PGSLIB
   $PGSMSG
   $PGSINC
   $SGIF90 - (SGI 64-bit compiler)
   $F90 - (Same as $SGIF90)
   $F90COMP = -O2 -c -64 -OPT:fprop_limit=4000 -OPT:fold_arith_limit=3106
   $HDFLIB - (SGI 64-bit, HDF4.1r1)
   $HDFINC
   $HDFEOSDIR
   $HDFEOSLIB
   $CC
   $CFLAGS = -64 -L -O
   $FCOMP = -w -64 -c -O

2. Change directory to the directory where you will install the Clouds Subsystem.

3. Uncompress and untar the cloud files:

   > **uncompress clouds_src_R2-042.tar.Z**
   > **tar xf clouds_src_R2-042.tar**
   > **uncompress clouds_anc_R2-042.tar.Z**
   > **tar xf clouds_anc_R2-042.tar**
   > **uncompress cloud_test_R2-042.tar.Z**
   > **tar xf clouds_test_R2-042.tar**

3.2 Compilation

1. It will be necessary to execute the smfcompile utility on file **FOOTPRINT_25500.t** and **PGS_SURFIO_26550.t**

   > cd $CERESHOME/clouds/smf
   > $CERESLIB/bin/smfcompile_all.csh

   to create the required PGS include and message files for Subsystem 4.4.

2. The executable for Subsystem 4.4 can be made by performing the following:

   > cd $CERESHOME/clouds/src/footprint
   > make

   This will produce the "**footprint**" executable in directory **$CERESHOME/clouds/bin.**

3. The input file needs to be copied into the preceeding subsystem (SS1) directory.

   > **cp $CERESHOME/clouds/data/input/IES/**
   CER_IES_TRMM- PFM_ValidationR1_00019.1997122800
   $CERESHOME/instrument/data/int_prod/
   CER_IES_TRMM- PFM_ValidationR1_00019.1997122800

4. Finally, this delivery includes the source code and makefile for a program **SSF_Compare** which will be used to compare the SSF_Int output file calculated at the DAAC to the matching files include in the **$CERESHOME/clouds/data/out_exp/data/SSF_Int** directory. To compile this program, perform the following steps:

   > cd $CERESHOME/clouds/test_suites/src/footprint/SSF_Compare
   > make

   This will create the executable **SSF_Compare** in directory

   $CERESHOME/clouds/test_suites/bin/footprint

   This completes the installation and compilation of Subsystem 4.4.

4.0 Test and Evaluation Procedures

This section provides general information on how to execute Subsystem 4.4.

4.1 Stand-alone Test Procedures

Execute the production script by performing the following

> cd $CERESHOME/clouds/bin
> Run_4.1-4.1P1 CERESHOME/clouds/rcf/CER4.1-4.1P1_PCF_TRMM-PFM-VIRS_ValidationR1_00003.1997122800

Note that this procedure first runs Subsystem 4.1 - 4.3, then sequentially runs Subsystem 4.4 without operator intervention.

Six files will be created by Subsystem 4.4:

$CERESHOME/clouds/data/out_comp/data/SSF_Int/
CER_SSFI_TRMM-PFM-VIRS_ValidationR1_00003.1997122800
$CERESHOME/clouds/data/out_comp/data/SSF_Int/
CER_SSFI_TRMM-PFM-VIRS_ValidationR1_00003.1997122800.met
$CERESHOME/clouds/data/out_comp/QA_Reports/
CER_FQC_TRMM-PFM-VIRS_ValidationR1_00003.1997122800
$CERESHOME/clouds/data/out_comp/QA_Reports/
CER_FQC_TRMM-PFM-VIRS_ValidationR1_00003.1997122800.met
$CERESHOME/clouds/data/out_comp/QA_Reports/
CER_FQCI_TRMM-PFM-VIRS_ValidationR1_00003.1997122800
and **$CERESHOME/clouds/data/out_comp/QA_Reports/**
CER_FQCI_TRMM-PFM-VIRS_ValidationR1_00003.1997122800.met

System resource requirements are approximately:

System Time:	26 minutes
Memory:	3000 K
Required Disk space:	1 GByte

4.2 Normal Operating Procedures

Subsystem 4.4 is intended to be executed in conjunction with and subsequent to Subsystem 4.1 - 4.3, which produces the very large temporary imager data file (Cookiedough) used as one of the two primary inputs for Subsystem 4.4. In addition to the imager data file from Subsystem 4.1 - 4.3, Subsystem 4.4 requires an hourly file of CERES footprint data (the Instrument Earth Scan (IES) file) which is produced by CERES Subsystem 1.0, (Instrument). Subsystem 4.4 produces an

intermediate SSF output file in binary, non-HDF format. This intermediate file is then processed by a separate Program Generation Executive (PGE), Subsystem 4.5 - 4.6 (Inversion) to complete the calculation of radiative fluxes at top-of-atmosphere and at the surface, and postprocesses the final SSF file to HDF format.

4.3 Evaluation Procedures

This section provides the procedure for evaluating the output from Clouds Subsystem 4.4. See the Test Plan for the Cloud Retrieval Subsystem for corresponding evaluation procedures for the output from Subsystem 4.1 - 4.3.

1. The footprint executable should have already been run so that files

   $CERESHOME/clouds/data/out_exp/data/SSF_Int/
   CER_SSFI_TRMM-PFM-VIRS_ValidationR1_00003.1997122800
   and
   $CERESHOME/clouds/data/out_comp/data/SSF_Int/
   CER_SSFI_TRMM-PFM-VIRS_ValidationR1_00003.1997122800

already exist. These paths and file names are hard-coded in program SSF_Compare.

2. In directory **$CERESHOME/clouds/test_suites/bin/footprint**

   enter:

   > SSF_Compare

   This will create a file:

   Compare_SSF_Int_1997122800

   in directory:

   $CERESHOME/clouds/test_suites/results/footprint

3. Check the last line of the above file to see if the comparison was SUCCESSFUL or UNSUCCESSFUL. We expect it to be successful.

   Provide a copy of this file to **c.m.mckinley@larc.nasa.gov**

4. Use the UNIX DIFF utility for the file pairs:

   $CERESHOME/clouds/data/out_comp/QA_Reports/
   CER_FQC_TRMM-PFM-VIRS_ValidationR1_00003.1997122800
   and
   $CERESHOME/clouds/data/out_exp/QA_Reports/
   CER_FQC_TRMM-PFM-VIRS_ValidationR1_00003.1997122800

Send results of these comparisons to:

Chuck McKinley **e-mail: c.m.mckinley@larc.nasa.gov**
Phone: (757) 827-4845 **Fax: (757) 825-9129**

4.4 Solutions to Possible Problems

1. All output files are opened with Status = NEW in Subsystem 4.4 software. These files must be removed before rerunning these test procedures. The symptom of a problem of this type is termination of the program during the initialization stage during the first few seconds of the test run. The specific problems can generally be found in the LogReport and/or LogStatus files.
2. The SSF_Int output file from Subsystem 4.4 will be approximately 200 MBytes. The Cookiedough imager data input file is nearly 800 MBytes. If all available disk space is consumed during a test run, the program will crash in unpredictable ways, and the output file will be corrupted.
3. Many problems encountered during compilation, linking, and execution are due to incorrect environment configuration. Generally, these problems make themselves readily apparent via compiler errors or termination of the program during the initialization stage during the first few seconds of execution.

APPENDIX A
Acronyms and Abbreviations

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Acronyms and Abbreviations

AVHRR	Advanced Very High Resolution Radiometer
CERES	Clouds and the Earth's Radiant Energy System
CERESlib	CERES Library
DAAC	Distributed Active Archive Center
EOS	Earth Observing System
EOS-AM	EOS Morning Crossing Mission
EOS-PM	EOS Afternoon Crossing Mission
ERBE	Earth Radiation Budget Experiment
ERBS	Earth Radiation Budget Satellite
FAPS	Fixed Azimuth Plane Scan
FOV	Field-of-View
IES	Instrument Earth Scans
IVT	Instrument Validation Tape
MODIS	Moderate-Resolution Imaging Spectroradiometer
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
PGE	Program Generation Executive
PSF	Point Spread Function
QC	Quality Control
SMF	Status Message File
SSF	Single Satellite CERES Footprint TOA and Surface Fluxes, Clouds
TOA	Top-of-the-atmosphere
TRMM	Tropical Rainfall Measuring Mission
VIRS	Visible Infrared Scanner

APPENDIX B
Directory Structure Diagram

Appendix B
Directory Structure Diagrams

The directory structure hierarchy for the Clouds Subsystem is depicted below.

/CERES/clouds

- **/bin**
- **/lib**
- **/src**
  - **/CloudsHDF**
  - **/Welch**
    - **/include**
    - **/lib**
  - **/avhrr**
  - **/flexs**
- **/data**
  - **/ancillary**
    - **/dynamic**
    - **/static**
      - **/BDM**
      - **/EPH**
      - **/Meta**
      - **/Other**
      - **/Tables**
      - **/Vint**
      - **/Welch**
      - **/footprint**
  - **/errlogs**
  - **/input**
    - **/IES**
    - **/VIRS**
    - **/SnowIce**
  - **/int_prod**
    - **/Cookie**
    - **/Offline**
  - **/out_comp**
    - **/QA_Reports**
    - **/browse**
    - **/data**
      - **/CRH**
      - **/CRH Update**
      - **/CloudVis**
      - **/SSF_Int**
      - **/Subset**

/data (continued)

- **/out_exp**
  - **/QA_Reports**
  - **/browse**
  - **/data**
    - **/CRH**
    - **/CRH_Update**
    - **/CloudVis**
    - **/SSF_Int**
    - **/Subset**
  - **/runlogs**
  - **/scr**
- **/rcf**
- **/smf**
- **/src**
  - **/footprint**
  - **/retrieval**
- **/test_suites**
  - **/bin**
    - **/footprint**
    - **/retrieval**
  - **/results**
    - **/footprint**
    - **/retrieval**
  - **/src**
    - **/footprint**
      - **/SSF_Compare**
    - **/retrieval**

APPENDIX C
File Description Tables

Appendix C
File Description Tables

C.1 Production Scripts and Executables

Table C.1-1. Production Scripts and Executables

File Name	Format	Description
Run_4.1-4.1P1.footprint	ASCII	Run script for footprint executable
Exe_4.1-4.1P1.footprint	Binary	Executable program for Subsystem 4.4

C.2 Processing Control Files (PCF), Metadata Control Files (MCF), and Status Message Files (SMF)

Table C.2-1. PCF, MCF, and SMF

File Name	Format	Description
CER4.1-4.1P1_PCF_TRMM-PFM-VIRS_ValidationR1_00003.1997122800	ASCII	Process Control File for combined PGE, Subsystems 4.1 - 4.4
PGS_25500	ASCII	Status Message File for Subsystem 4.4
PGS_SURFIO_26550	ASCII	Status Message File for SARB IO module
CFSSFIAB.MCF	ASCII	Metadata Control File for intermediate SSF
CFQC__AB.MCF	ASCII	Metadata Control File for ASCII quality control report
CFQCI_AB.MCF	ASCII	Metadata Control File for binary quality control report

C.3 Production Makefiles

Table C.3-1. Production Makefile

File Name	Format	Description
Makefile	ASCII	Makefile for Subsystem 4.4

C.4 Ancillary Input Data

Table C.4-1. Ancillary Input Data

File Name	Format	Description
CER_FPARAM_TRMM-PFM-VIRS_00003.epoch	ASCII	Contains science inputs for footprint control
CER_FPSFC10_CERES_00003.epoch	ASCII	Contains CERES point spread function
CER_EREFL_CERES_00003.epoch	ASCII	Contains data for surface reflectivity calculations

C.5 Primary Input Data

Table C.5-1. Primary Input Data

File Name	Format	Description
CER_IPD_TRMM-VIRS_ValidationR1_00003.1997122800	Binary	Imager data file containing pixel-level cloud property data
CER_IES_TRMM-PFM_ValidationR1_00019.1997122800	Binary	Simulated CERES footprint data derived from ERBE IVT data products
CER_IPD_TRMM-VIRS_ValidationR1_00003.1997122800.met	ASCII	Metadata load file for Imager data file
CER_IES_TRMM-PFM_ValidationR1_00019.1997122800.met	ASCII	Metadata load file for simulated CERES footprint data

C.6 Output Data Files (Expected Results)

Table C.6-1. Output Data Files (Expected Results)

File Name	Format	Description
CER_SSFI_TRMM-PFM-VIRS_ValidationR1_00003.1997122800	Binary	Intermediate SSF output file produced by Subsystem 4.4
CER_FQC_TRMM-PFM-VIRS_ValidationR1_00003.1997122800	ASCII	ASCII-format standard QC report file generated by Subsystem 4.4 for each hour of data processed
CER_FQCI_TRMM-PFM-VIRS_ValidationR1_00003.1997122800	Binary	Binary-format QC datafile generated by Subsystem 4.4, to be postpro-cessed
CER_SSFI_TRMM-PFM-VIRS_ValidationR1_00003.1997122800.met	ASCII	Metadata load file for intermediate SSF output file
CER_FQC_TRMM-PFM-VIRS_ValidationR1_00003.1997122800.met	ASCII	Metadata load file for ASCII-format standard QC report file
CER_FQCI_TRMM-PFM-VIRS_ValidationR1_00003.1997122800.met	ASCII	Metadata load file for binary-format QC datafile

C.7 Output Data Files (Production Results)

Production results will be the same as specified in Table C.6-1 above.

C.8 Output Temporary Data Files

Not applicable to Subsystem 4.4.

C.9 Error and Status Message Files (Expected Results)

Not delivered with Subsystem 4.4.

C.10 Test Evaluation Software

Table C.10-1. Test Evaluation Software

File Name	Format	Description
SSF_Compare	Binary	Executable program to compare expected and computed Compare_SSF_Int_1997122800 output files